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TO: Chief of Naval Research, Arlington, VA 22217
Attention: Engineering Psychology Programs, Code 455
Dr. John J. O'Hare

FROM: Professor Gordon H. Robinson, Dept. of Industrial Engineering,
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RE: Final Report, Contract N00014-75-C-0364; Work Unit NR 197-028

I. This document constitutes a final report of research under Contract N00014-75-C-0364 Work Unit NR 197-028 between the Office of Naval Research, Engineering Psychology Programs and the Regents of the University of Wisconsin. This contract covered the period Nov. 1, 1974 to June 30, 1978.

II. The purpose of this contract was to conduct laboratory research exploring the interactive dynamics of the eye and head in settings arguably related to such person/machine systems as high speed aircraft. Two goals were set: 1) advance of the scientific understanding of eye and head movement, and 2) specific assistance for analysts or designers of systems requiring relatively fast, wide angle search. Important progress was made toward both goals but neither were achieved in the breadth of settings or independent variables originally proposed. Eye measurement instrumentation problems and eye/head data processing problems beset the work from the start - as it seems to have slowed most eye movement research programs.

III. The results of the research conducted under this contract are listed below under seven headings: 1) eye/head patterns, 2) ongoing tasks, 3) initial compensation, 4) reaction time, 5) saccades, 6) dynamic compensation, and 7) synthesis for application.

1) Eye/head patterns

Prior to our work it was not possible to construct the total time pattern of coordinated eye and head movements from published research. Prior (and much contemporary) research has concentrated on small refixation angles and has fixed the head to assist in precise eye measurement. Early, exploratory work (immediately prior to this contract) indicated that very substantive changes - both qualitative and quantitative -

occurred when three "realism" factors were included: 1) wide angle, such as scans across an instrument panel or between the panel and direct contact vision, 2) free head, and 3) search interrupting other ongoing tasks, such as almost always occurs in vehicle control (Robinson, Koth, and Ringenbach, 1976).

The total form of these patterns as a function of refixation angle, target illumination, and target location certainty was first shown in Robinson and Rath (1976). An earlier report (Robinson & Bond, 1975) had brought forth the effect of the ongoing, competitive task on the early stages of eye/head movement. A later report (London & Robinson, in preparation) concentrates on another issue heretofore poorly documented, the dynamic compensation pattern which takes place when several targets must be serially checked for possible validity.

2) Ongoing tasks

In a laboratory simulation we noted a reversal of the classical "eye before head" findings prevalent or strongly inferred in the literature. It was clear that the simple imposition of an ongoing task, such as vehicle control, could have a profound effect on both the timing and subsequent pattern of visual search dynamics. Extensive study of manual control dimensions (e.g., bandwidth, system dynamics) failed to yield large effects, however, and it now appears that the presence, per se, of such a task is a large contributor to change (Robinson & Bond, 1975; Nelson, London, & Robinson, 1978). As would be expected, a payoff matrix on the ongoing task versus search has an important effect (London, Bice, & Robinson, in preparation). The comparatively large effects found cast a considerable shadow over the practical, human factors applicability of most previous laboratory research on eye movements.

3) Initial compensation

The main qualitative change in the pattern of eye/head movement when the ongoing task was superimposed was tentatively identified as

eye-head compensation. This phenomenon is now an established fact, although the precise conditions under which it will occur still elude tight specification. Nelson, London and Robinson (1978) note large inter-subject differences - a "style" issue not unrelated to "mirror" search style issues in automobile driving. The effects of experience, training and systems setting on this variable remain undiscovered.

As already mentioned, above, Robinson and Bond (1975) describe the effects of a variety of manual control dimensions on initial compensation and London, Bice and Robinson (in preparation) describe the effects of explicit task payoff structures.

4) Reaction time

The most significant quantitative finding in our work is the substantial increase in eye reaction time related to almost any "reality" imposed in the experiment. It would appear that the classical "200 msec" eye latency is largely, if not entirely, an abstract laboratory phenomenon. Nelson, London and Robinson (1978) summarize our findings here.

5) Saccades

Our significant addition to the previous, fairly extensive knowledge of saccadic movement properties is confirmation of the lack of effect of many practical (human factors) variables. It could probably be inferred from many writings on saccades that task and environmental variables would have little or no effect, but it is quite reasonable for experimentally-oriented researchers to remain skeptical of such generalizations. Generalizations from past work would have been particularly difficult because of the small size and involuntary nature of the saccades in much previous work. Robinson (1978) summarizes our findings here, while London and Robinson (in preparation) present experimental detail and quantification.

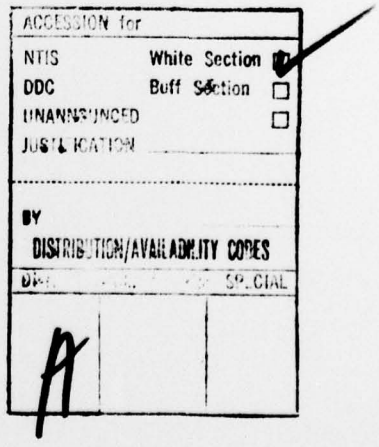
6) Dynamic compensation

The precise nature of eye and head compensatory movement during potential target inspection has heretofore not been clearly shown. It

is here that the limitations of past instrumentation and fixed-head paradigms are the most dramatically shown. The patterns are shown in Robinson and Rath (1976) and are the subject of independent variable manipulation and interpretation in London and Robinson (in preparation). Robinson (1978) extracts a brief practical note on this phenomenon.

7) Synthesis for application

It was clear at the outset of this research project that, while there remained (and still remain) many unknown scientific facts concerning eye/head movement, the more important constraint on the use of existing knowledge by systems designers was the lack of synthesis of knowledge into a package suitable for their use. Human factors handbooks (vision sections) were (and should still be) criticized for being an unrelated collection rather than a purposive synthesis. Robinson (1978) has written a move toward the latter concept. We hope that future handbooks and other human factors publications will more clearly recognize this issue.



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Reports

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